

# New Digenetic Trematodes from Hawaiian Fishes, I<sup>1</sup>

SATYU YAMAGUTI

THIS REPORT describes thirteen new species of digenetic trematodes, each of which represents a new genus. Although some of the digenetic trematodes of Hawaiian fishes have been worked out by American authors, such as Dr. H. W. Manter, Dr. W. E. Martin, and Mrs. M. H. Pritchard, my investigations on the same group of parasites, carried out under a grant (GB-78) from the National Science Foundation, have revealed that there still are large numbers of undescribed species. It is really surprising that American authors have failed to report the occurrence of didymozoid trematodes, which are not uncommon in the Hawaiian fishes. The major part of the results obtained in our survey of the Hawaiian trematodes will be published in two volumes of monographs, in which every species found by us will be treated taxonomically with related commentary.

Fishes were collected at the fish market of Honolulu by my assistant, Mr. Shunya Kamegai, and were examined by him for parasites as soon as possible.

The worms were fixed just overnight under appropriate cover glass pressure in acetic Schaudinn's solution; on the following morning, after removal from the slides in water, they were re-fixed in a sufficient quantity of acetic Schaudinn's solution, in which they were not allowed to stay for more than three hours (in order to facilitate removal of excess mercury by treating with iodine in 95% alcohol). Heidenhain's hematoxylin was consistently used for staining the specimens fixed in acetic sublimate, and 1% oxalic acid, when necessary, for bleaching the overstained specimens, the differentiation of which could not be adequately controlled by 2.5% solution of ferric ammonium sulfate. However, for the didymozoid trematodes which may be fixed with 10% formol solution, acetic

formol alcohol, or acetic Schaudinn's solution, with or without cover glass pressure; staining with Delafield's hematoxylin (commercial Delafield's with acetic acid added in 4%) is preferable in order to differentiate fully the male organs from the female organs; counterstaining with eosin is not necessary in this case. This method was also applied to massive trematodes of other families, which were, however, subjected to strong cover glass pressure by means of a wire compressorium.

The figures were drafted by Mr. S. Kamegai, with the aid of a camera lucida for the whole specimens but drawn freehand for particular structures. They were traced and finished for publication by Mrs. Ikuko Yamaguti.

The type specimens of all new species will be deposited in U. S. National Museum, Helminthological Collection at the Beltsville Parasitological Laboratory. In this report they are given accession numbers\* (headed by S. Y.) consecutive to those of the first report.

Thanks are due to the National Science Foundation, Dr. G. W. Chu, Department of Microbiology, University of Hawaii, Dr. W. A. Gosline, Department of Zoology, University of Hawaii, my assistant, Mr. S. Kamegai, and my wife, Mrs. Ikuko Yamaguti.

The new genera described herein are assigned to different families as follows:

## I. Lepocreadiidae Nicoll, 1935

### Bulbocirrinae n. subf.

#### 1. *Bulbocirrus aulostomi* n. gen., n. sp.

### Lepocreadiinae Odhner, 1905

#### 2. *Neoalolepidapedon hawaiiense* n. gen., n. sp.

## II. Acanthocolpidae Lühe, 1909

### Acanthocolpinae Lühe, 1906

#### 3. *Pseudacaenodera cristata* n. gen., n. sp.

## III. Hemiuridae Lühe, 1901

### Albulatrematinae n. subf.

#### 4. *Albulatrema ovale* n. gen., n. sp.

<sup>1</sup> Contribution No. 225, from Hawaii Marine Laboratory, University of Hawaii, Honolulu. Manuscript received March 16, 1964.

- Bunocotylinae Dollfus, 1950
5. *Pseudobunocotyla awa* n. gen., n. sp.
- Quadrifoliovariinae n. subf.
6. *Quadrifoliovarium pritchardi*  
n. gen., n. sp.
- IV. Lobatovitelliovariidae n. fam.
7. *Lobatovitelliovarium fusiforme*  
n. gen., n. sp.
- V. Didymozoidae Poche, 1907
- Didymozoinae (Ishii, 1935)
8. *Lobatocystis yaito* n. gen., n. sp.
- Nematobothriinae Ishii, 1935
9. *Allonematobothrium epinepheli*  
n. gen., n. sp.
10. *Allometanematobothrioides  
lepidocybii* n. gen., n. sp.
11. *Metanematobothrioides opakapaka*  
n. gen., n. sp.
12. *Nematobothrioides kalikali*  
n. gen., n. sp.
13. *Neonematobothrium kawakawa*  
n. gen., n. sp.
1. *Bulbocirrus aulostomi* n. gen., n. sp.

Fig. 1 A-C

HABITAT: Small intestine of *Aulostomus chinensis* (local name "nunu"); Hawaii.

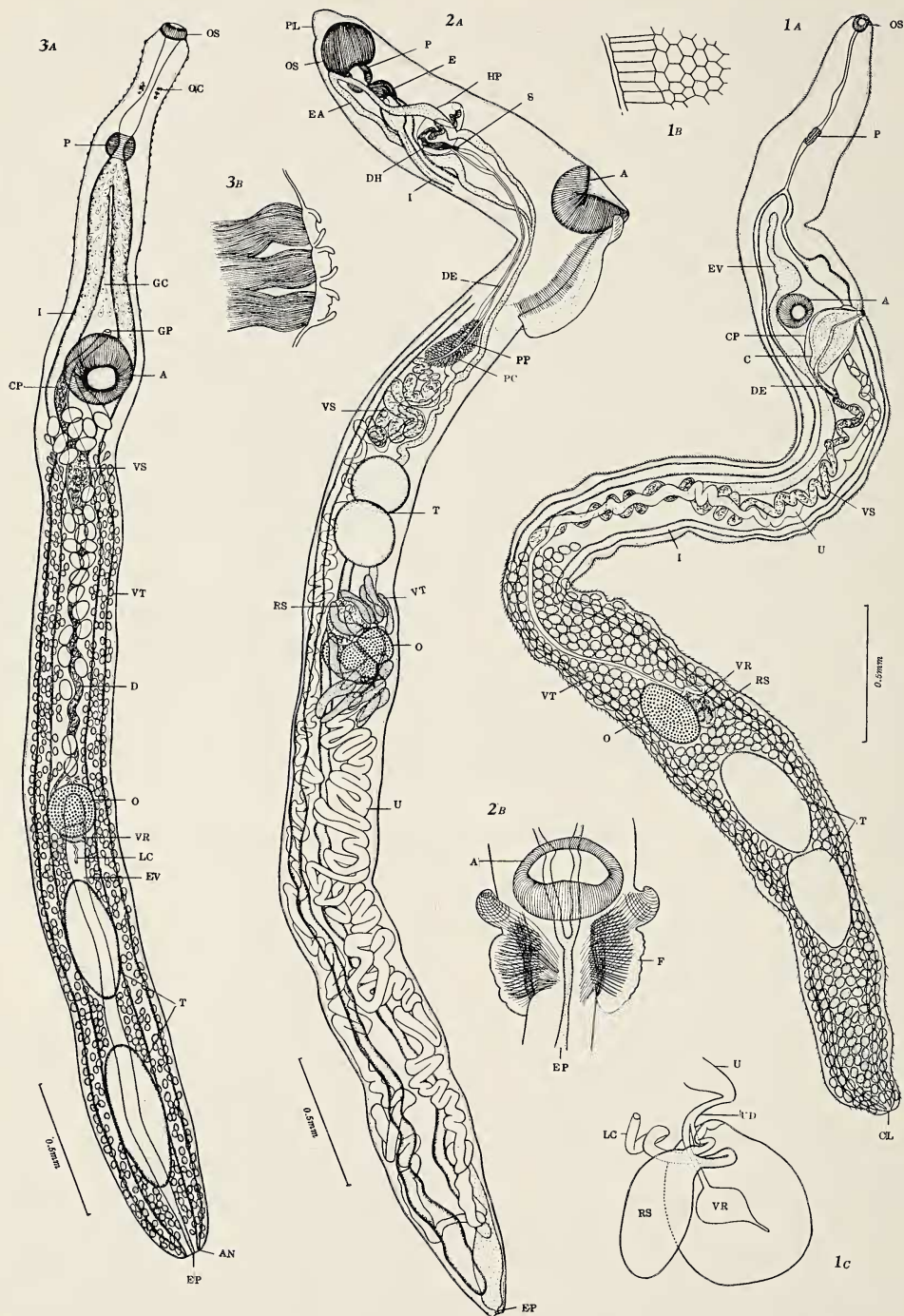
HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 19.

DESCRIPTION (based on eight whole mounts): Body long, slender, tapering anteriorly, 3.7-12.5 mm long, with maximum width of 0.2-0.55 mm in posterior third of body. Cuticle beset with minute spines, densely on greater anterior part of body, but sparsely on posterior third. Oral sucker ventroterminal, 30-80 × 40-90 μ; prepharynx slender, 0.2-0.7 mm long; pharynx cylindrical, narrow, muscular, 50-120 × 30-70 μ; esophagus slender, 0.1-0.3 mm long, bifurcating at a distance of 0.16-0.83 mm from acetabulum; left cecum greatly dilated at the beginning at level of acetabulum, and right cecum also dilated a little further behind in the type. At the posterior tip of the body is a shallow cloaca, into which the two ceca open separately, one on each side of the excretory vesicle. Acetabulum 0.08-0.15 × 0.08-0.17 mm, situated posterior to middle of anterior third of body.

Testes ellipsoidal, 0.3-0.8 × 0.19-0.43 mm, directly tandem in caudal third of body. Seminal vesicle tubular, very long, more or less swollen at proximal end, winding in median field between anterior end of vitellaria and cirrus pouch with its terminal portion differentiated into muscular ejaculatory duct enclosed in cirrus pouch. Cirrus massive, 0.1-0.45 × 0.05-0.2

ABBREVIATIONS USED IN FIGURES

A	acetabulum	M	metraterm
AN	anus	O	ovary
C	cirrus	OC	eye spot
CL	cloaca	OS	oral sucker
CP	cirrus pouch	P	pharynx
D	vas deferens	PC	prostatic cell
DE	ductus ejaculatorius	PL	preoral lobe
DH	ductus hermaphroditicus	PP	pars prostatica
E	esophagus	RS	receptaculum seminis
EA	excretory arm	SP	sphincter
EP	excretory pore	T	testis
EV	excretory vesicle	U	uterus
GC	gland cell	UD	uterine duct
GP	genital pore	VR	vitelline reservoir
HP	hermaphroditic pouch	VS	vesicula seminalis
I	intestine	VSE	vesicula seminalis externa
LC	Laurer's canal	VT	vitellarium



FIGS. 1-3. 1, *Bulbocirrus aulostomi* n. gen., n. sp. 1A, holotype, ventral view; 1B, part of wall of cirrus; 1C, ovarian complex, dorsal view. 2, *Quadrifoliovarium pritchardi* n. gen., n. sp. 2A, holotype, lateral view; 2B, postacetabular adhesive flaps, ventral view. 3, *Pseudacaenodera cristata* n. gen., n. sp. 3A, holotype, ventral view; 3B, cervical armature, lateral view.



mm, lined with closely packed, columnal structures and provided with a thin layer of circular muscle fibers, with a very narrow axial lumen which opens at the tip of the conical end of the cirrus. No prostatic complex. Cirrus pouch saccular,  $0.14\text{--}0.42 \times 0.08\text{--}0.3$  mm, with thin wall of mainly circular muscle fibers, almost completely occupied by cirrus and ejaculatory duct. Genital atrium not well developed, opening on left margin of body at level of posterior border of acetabulum.

Ovary oval,  $0.17\text{--}0.35 \times 0.12\text{--}0.26$  mm, situated in median line or a little out of it at junction of middle with posterior third of body, separated from anterior testis by vitellaria. Receptaculum seminis retort-shaped,  $0.14\text{--}0.2 \times 0.04\text{--}0.11$  mm, overlapping ovary on its dorso-lateral side. The germiduct arising from the anterior end or anterodorsal part of the ovary winds its way backwards or laterad and joins the seminal receptacle at its anterior end where the Laurer's canal is given off; then it unites with the vitelline duct to lead into the uterine duct. Laurer's canal winding, opening dorso-lateral to ovary. Uterus winding forward from in front of ovary alongside vas deferens; metratrem crossing cirrus pouch dorsally and opening into genital atrium immediately anterior to conical tip of cirrus; eggs elliptical, thick-shelled,  $46\text{--}65 \times 25\text{--}37 \mu$ . Vitelline follicles comparatively large, extending from posterior end of seminal vesicle to posterior extremity, confluent in median field between ovary and anterior testis as well as in posttesticular area; vitelline reservoir dorsal or lateral to ovary. Excretory vesicle tubular, middorsal, reaching as far forward as intestinal bifurcation; excretory pore terminal, forming cloaca.

**DISCUSSION:** This genus is characterized by the structure of the male terminal genitalia, the possession of a cloaca and an extremely long tubular seminal vesicle. Though resembling lepecreidiids in general anatomy, especially in the ovarian complex, extent of the vitellaria, and excretory vesicle, it differs from any of the known genera in the cirrus being developed as a massive organ and occupying almost the entire cirrus pouch and opening on the postacetabular margin of the body. The fact that the seminal vesicle develops outside the cirrus

pouch in the form of an extremely long winding tubule is also one of the important differential characters. I prefer to propose a new subfamily Bulbocirrinae, placing it near the subfamily Lepocreadiinae.

#### BULBOCIRRINAE n. subf.

**SUBFAMILY DIAGNOSIS:** Lepocreadiidae. Body slender, spinose. Oral sucker small, prepharynx long. Cloaca present. Acetabulum in anterior third of body. Testes tandem, in posterior part of body. Seminal vesicle tubular, very long, followed by muscular ejaculatory duct which is enclosed in cirrus pouch. Cirrus massive, enormous, occupying almost entire cirrus pouch. No internal seminal vesicle. Genital pore marginal, postacetabular. Ovary pretesticular. Uterus winding between ovary and cirrus pouch. Vitellaria posterior, not very extensive. Excretory vesicle tubular.

#### *Bulbocirrus* n. gen.

**GENERIC DIAGNOSIS:** Lepocreadiidae, Bulbocirrinae. Body tapering anteriorly, with maximum width in caudal third. Oral sucker small, ventroterminal; prepharynx very long; pharynx cylindrical; ceca opening into cloaca at posterior extremity. Acetabulum comparatively small. Testes directly tandem, posterior. Seminal vesicle very long, winding. No prostatic complex; ejaculatory duct muscular; cirrus massive, bulbous, occupying cirrus pouch together with ejaculatory duct. Genital atrium not well developed; common genital pore marginal, postacetabular. Ovary separated from anterior testis by vitellaria; receptaculum seminis and Laurer's canal present. Uterus long, winding; eggs thick-shelled. Vitellaria in posterior half of body. Excretory vesicle tubular, reaching to near intestinal bifurcation. Intestinal parasites of marine teleosts.

**TYPE SPECIES:** *B. aulostomi* n. sp., in *Aulostomus chinensis*; Hawaii.

#### 2. *Neoallopepidapedon hawaiiense*

n. gen., n. sp.

Fig. 7 A-B

**HABITAT:** Stomach and intestine of *Fistularia petimba*; Hawaii.



HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 20.

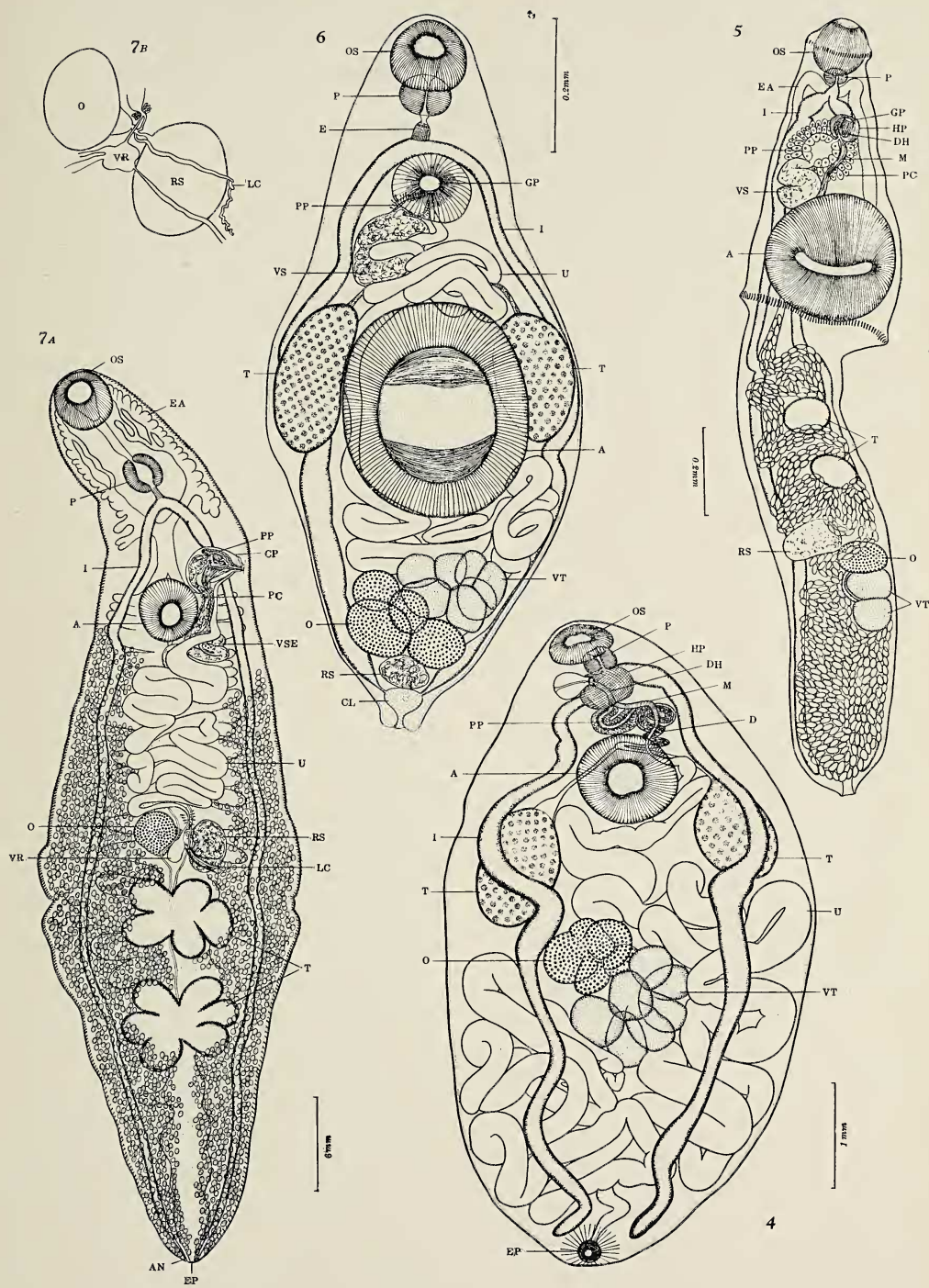
DESCRIPTION (based on 13 mature whole mounted specimens): Body elongate fusiform, with blunt extremities, 3.75–11 mm in length with maximum width of 0.8–2.3 mm in ovario-testicular region where the lateral margins are more or less irregularly crenulated; cuticle thick, beset throughout with minute spines. Oral sucker ventroterminal,  $0.23\text{--}0.5 \times 0.23\text{--}0.5$  mm; prepharynx  $0.13\text{--}0.55$  mm long; pharynx spherical,  $0.18\text{--}0.32$  mm in diameter; esophagus  $30\text{--}200$   $\mu$  long; ceca simple and wide anteriorly, but may be diverticulate on outer side in hind-body, opening outside separately, one on each side of excretory pore, at posterior extremity. Acetabulum  $0.28\text{--}0.64$  mm in diameter, situated at or near posterior end of anterior third of body.

Testes deeply lobed,  $0.18\text{--}1.3 \times 0.25\text{--}1.2$  mm, tandem; anterior testis usually 5-lobed, at posterior end of middle third of body, separated from ovary as well as from posterior testis by vitellaria; posterior testis usually 6-lobed, at anterior part of posterior third of body. Seminal vesicle tubular,  $50\text{--}170$   $\mu$  wide, closely winding posterodorsal to acetabulum in the fully gravid type, but extending farther backward in young individuals, a little to left of median line, with its anterior portion surrounded by prostate cells, whose ducts enter the cirrus pouch at its posterior end to discharge into the pars prostatica enclosed in the pouch; the anterior end of the seminal vesicle penetrates the posterior end of the cirrus pouch, and forms a definite, distally swollen, internal seminal vesicle which leads into the pars prostatica with a constriction or demarcation between. Pars prostatica muscular, bulbous, with its distal end differentiated into a short cirrus. Cirrus pouch saccular, thin-walled,  $0.2\text{--}0.6 \times 0.09\text{--}0.4$  mm, extending obliquely or transversely from anterosinistral edge of acetabulum to genital pore, containing distal end of external seminal vesicle, internal seminal vesicle, very strongly developed pars prostatica, numerous prostatic ducts coming from prostate cells surrounding distal portion of external seminal vesicle, and a short stout cirrus. Genital

atrium muscular, lined with thick cuticle, opening sinistrosubmarginally at pre-acetabular level.

Ovary subglobular to longitudinally elongated oval,  $0.06\text{--}0.56 \times 0.06\text{--}0.4$  mm, at or behind equatorial level, slightly to right of median line. Germiduct arising from left side of ovary, strongly constricted at its origin, giving off Laurer's canal just before joining seminal receptacle; seminal receptacle large,  $0.2\text{--}0.5 \times 0.15\text{--}0.4$  mm in fully mature specimens, situated to left of ovary, a little in front of anterior testis. Laurer's canal opening outside dorsal or immediately sinistral to seminal receptacle. Uterus tightly coiled in intercecal field between ovary and acetabulum; metraterm running alongside male terminalia. Eggs oval,  $44\text{--}54 \times 27\text{--}37$   $\mu$  in life. Vitelline follicles comparatively small, circumcecal, commencing at level of posterior end of acetabulum on the right, but a little more posteriorly on the left, intruding into space between ovary and anterior testis as well as into intertesticular space without meeting in median line, but almost confluent in posttesticular area; vitelline reservoir oval,  $85$   $\mu$  wide in the type, up to  $0.28 \times 0.18$  mm, situated ventrally between ovary and seminal receptacle. Excretory vesicle Y-shaped; its stem with numerous lateral diverticles reaching to intestinal limbs or overlapping them; in posttesticular area these lateral diverticles are simple, but the remaining are irregularly subdivided dendritically. Between the acetabulum and the ovary the diverticles anastomose with one another in median line in mature specimens, so that the primary median stem recognized in immature specimens is now replaced by anastomosing diverticles. Immediately behind the intestinal bifurcation the median stem divides into two lateral arms, each of which gives off an inner secondary branch communicating anteriorly with the main lateral branch of its own side; excretory pore terminal, not forming cloaca.

DISCUSSION: This new genus closely resembles *Allolepidapedon* Yamaguti, 1940, but the general body shape, the peculiar structure of the excretory vesicle, and the presence of two separate anal openings instead of the cloaca prevent its being identified with the latter genus. It is defined as follows:



FIGS. 4-7. 4, *Albulatrema ovale* n. gen., n. sp.; holotype, ventral view. 5, *Pseudobunocotyla awa* n. gen., n. sp.; holotype, ventral view. 6, *Lobatovitelliovarium fusiforme* n. gen., n. sp.; holotype, ventral view. 7, *Neoalolepidapedon hawaiiense* n. gen., n. sp. 7A, holotype, ventral view. 7B, ovarian complex, ventral view.



*Neoallopeidapedon* n. gen.

GENERIC DIAGNOSIS: Lepocreadiidae, Lepocreadiinae Odhner, 1905. Body elongate, fusiform, more or less crenulated laterally in hind-body, covered with spines. Oral sucker ventro-terminal; prepharynx long, esophagus short, ceca opening outside, one on each side of excretory pore. Acetabulum comparatively small, at or near posterior end of anterior third of body. Testes lobate, median, tandem, in posterior half of body. Seminal vesicle tubular, winding, extending back of acetabulum to variable extent, with its distal portion surrounded by prostate cells, the ducts of which penetrate the posterior end of the cirrus pouch and empty into the pars prostatica. Cirrus pouch thin-walled, extending between acetabulum and genital pore, containing vesicula seminalis interna, well developed pars prostatica and stout cirrus. Genital pore marginal or submarginal, at a pre-acetabular level. Ovary pretesticular. Receptaculum seminis and Laurer's canal present. Uterus coiled between ovary and acetabulum. Metratrum differentiated. Eggs oval, numerous, moderately large. Vitelline follicles comparatively small, extending along ceca for their greater part. Excretory vesicle Y-shaped in fundamental pattern, but strongly diverticulate throughout its length, reticulate between ovary and acetabulum, with terminal pore, not forming cloaca. Gastro-intestinal parasites of marine teleosts.

TYPE SPECIES: *N. hawaiiense* n. sp., in *Fistularia petimba*; Hawaii.

3. *Pseudacaenodera cristata* n. gen., n. sp.

Fig. 3 A-B

HABITAT: Small intestine of *Conger marginatus*; Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 21.

DESCRIPTION (based on six whole mounts): Body slender, tapering anteriorly and narrowed in region of prepharynx,  $2.4-4.5 \times 0.3-0.42$  mm; a little swollen immediately behind oral sucker; the neck region from this swelling down to the acetabular zone is provided on each lateral margin and on the ventromedian field with irregular longitudinal rows of sharp-edged discoid cuticular projections, which are most prom-

inent in the postoral zone and gradually diminish posteriorly. Numerous strong parenchymatous muscles are attached to the base of each projection in this postoral area and fill the whole space between the body wall and the prepharynx, so that this portion probably functions as a powerful accessory attachment apparatus. Oral sucker terminal, bowl-shaped, with wide aperture,  $50-63 \times 78-110 \mu$ . Prepharynx  $0.23-0.35$  mm long, considerably enlarged just in front of pharynx, with a compact or dissociated eye spot on each side at about its middle. Pharynx barrel-shaped,  $60-100 \times 76-110 \mu$ , with wide lumen. Esophagus wide, about  $80-100 \mu$  long, bifurcating near middle of forebody. Ceca also wide in forebody; esophagus and anterior portion of ceca surrounded dorsally and ventrally by numerous gland cells which are irregular in shape and contain cytoplasmic granules, probably representing residue of the accessory digestive metacercarial glands. Both ceca opening independently at posterior extremity, one on each side of excretory pore. Acetabulum  $0.18-0.24 \times 0.17-0.25$  mm, situated at posterior part of anterior third of body.

Testes elliptical, tandem, in posterior third of body, separated one from the other by vitellaria; anterior testis  $0.22-0.42 \times 0.16-0.23$  mm, posterior testis  $0.28-0.51 \times 0.14-0.22$  mm. Cirrus pouch elongated claviform,  $0.34-0.5 \times 0.04-0.1$  mm, almost entirely occupied by seminal vesicle, not containing prostatic cells, in contrast with that of *Acaenodera placophora* Manter and Pritchard, 1960. No vesicula seminalis externa. The attenuated anterior portion of the seminal vesicle appears to join the metratrum dorsal to the acetabulum. Genital sinus tubular, opening midventrally on anterior border of acetabulum.

Ovary round,  $0.09-0.16$  mm in diameter, situated medianly a little anterior to fore testis, from which it is separated by the vitellaria. Laurer's canal opening almost middorsally between ovary and anterior testis. No seminal receptacle. Uterus winding in median field between ovary and acetabulum; eggs oval, moderately large,  $75-80 \times 52-58 \mu$  in life. Vitellaria extending uniformly in lateral fields around intestine from level of seminal vesicle to posterior extremity; vitelline reservoir com-



pact, overlapping posterior end of ovary. Excretory vesicle tubular, long, reaching to ovary, with terminal pore between two ani.

**DISCUSSION:** This genus is undoubtedly closely related to *Acaenodera* Manter and Pritchard, 1960, but differs from it distinctly in possessing discoid, cuticular, cervical projections instead of spines. I prefer to regard this difference as of generic importance. It is defined as follows:

*Pseudacaenodera* n. gen.

**GENERIC DIAGNOSIS:** Acanthocolpidae, Acanthocolpinae. Body slender, armed in cervical region with longitudinal rows of flattened conical or discoid cuticular projections both ventrally and laterally. Oral sucker terminal, bowl-shaped, prepharynx very long, widened posteriorly; pharynx barrel-shaped, esophagus very short, ceca opening outside by separate ani at posterior extremity. Acetabulum larger than oral sucker, less than one-third of body length from anterior extremity. Testes tandem, in posterior third of body. Cirrus pouch claviform, almost completely occupied by seminal vesicle, containing neither cirrus nor prostatic complex. Genital sinus tubular, opening medianly on anterior border of acetabulum. Ovary median, pretesticular. No seminal receptacle. Laurer's canal present. Vitellaria extending along ceca from level of seminal vesicle to posterior extremity; vitelline reservoir overlapping ovary. Uterus winding in intercecal field between ovary and acetabulum; eggs oval, medium-sized. Excretory vesicle long, tubular, with terminal pore. Parasitic in intestine of marine teleosts.

**TYPE SPECIES:** *P. cristata* n. sp., in *Conger marginatus*; Maui island, Hawaii.

4. *Albulatrema ovale* n. gen., n. sp.

Fig. 4

**HABITAT:** Swimbladder of *Albula vulpes* (local name "oio"); Hawaii.

**HOLOTYPE:** U. S. Nat. Mus. Helm. Coll., S.Y. No. 22.

**DESCRIPTION** (based on 20 strongly flattened, whole mounts): Body subglobular to oval or pyriform, 3.4–6.2 mm long, 2.5–4.5 mm wide in midregion. Cuticle smooth; outer circular and inner longitudinal subcuticular muscles well

developed; parenchyma loose-meshed, traversed by strong muscle bundles running in different directions. Oral sucker terminal,  $0.3\text{--}0.4 \times 0.5\text{--}0.7$  mm, directly followed by muscular pharynx  $0.3\text{--}0.35$  mm long by  $0.15\text{--}0.45$  mm wide. Esophagus very short; ceca wide, undulating, ventrolateral or ventral to testis, lateral or ventral to ovary and vitelline gland, and ventral to uterus, terminating at posterior extremity, one on each side of excretory vesicle. Acetabulum  $0.6\text{--}0.85 \times 0.65\text{--}0.98$  mm, situated at posterior half of anterior third of body.

Testes oval,  $1.0\text{--}1.5 \times 0.54\text{--}1.1$  mm, placed almost symmetrically posterolateral to acetabulum; vas efferens arising from anterior end of each testis, joining together in median line dorsal to anterior part of acetabulum; vas deferens narrow proximally, but becoming wider and strongly muscular, forming a conspicuously winding or convoluted mass which is sharply delimited from the surrounding parenchyma by a capsule of apparently muscular element anterodorsal to acetabulum; seminal vesicle absent; pars prostatica sigmoid, strongly muscular, surrounded by well-developed prostate cells which are sharply delimited from the surrounding parenchyma by a distinct capsule of connective (?) or muscular fibers, joining metraterm at its anterior end to form eversible hermaphroditic duct. When everted, this duct forms a smooth bulbous prolapsus  $0.27\text{--}0.4$  mm wide and projecting out of the genital pore ventral to the pharynx. Hermaphroditic pouch bulbous,  $0.33\text{--}0.5 \times 0.45\text{--}0.5$  mm, consisting of a compact mass of longitudinal and circular muscles. Whether there is a genital atrium or not could not be ascertained.

Ovary  $0.45\text{--}1.15 \times 0.6\text{--}1.2$  mm, divided into four or five globular to oval lobes, situated close to center of body, a little to right or left of median line. Shell gland complex immediately posterolateral to ovary. Uterus coiling at first on right side of body posterior to right testis, dorsal to right cecum, then crossing over to left side across excretory vesicle ventrally, and winding on left side of body posterior to left testis, dorsal to left cecum, finally occupying space between ovary and acetabulum, and between acetabulum and left testis; metraterm sigmoid, running ventral to convoluted vas deferens and

pars prostatica. Eggs oval,  $17-23 \times 8-13 \mu$  in life. Vitellaria immediately posterior or posterosinistral to ovary, divided into six or seven, rarely eight, oval to pyriform, rosette-shaped lobes, measuring as a whole 0.75–1.5 mm by 0.9–1.9 mm. Excretory vesicle Y-shaped, opening ventroterminally or actually ventrally at a postvitellarian level, depending on the degree of pressure applied on the body of the parasite; excretory arms united anteriorly dorsal to oral sucker.

DISCUSSION: According to its general anatomy this new genus undoubtedly belongs to the family Hemiuridae, but cannot be referred to any known subfamilies under this family. I prefer to propose a new subfamily, Albulatrematinae, placing it near Lecithophyllinae Skrjabin and Guschansk., 1954 (= Hysterolecinthinae Yamaguti, 1958).

#### ALBULATREMATINAE n. subf.

SUBFAMILY DIAGNOSIS: Hemiuridae. Body subglobular, or oval to pyriform, without tail. Oral sucker and pharynx well developed. Ceca not united posteriorly. Acetabulum in anterior third of body. Testes nearly symmetrical, posterolateral to acetabulum. Distal portion of vas deferens strongly muscular, convoluted and enclosed in apparently muscular capsule. No seminal vesicle. Pars prostatica strongly muscular, surrounded by prostate cells which are sharply delimited from surrounding parenchyma by muscular capsule, joining metraterm to form hermaphroditic duct, which is enclosed in a massive muscular pouch, and which may be everted out of the genital pore in form of a bulbous prolapsus. Genital pore ventral to pharynx or esophagus. Ovary lobed, submedian, in middle third of body. Vitellaria rosette-shaped, postovarian. Uterine coils occupying all available space of hindbody; eggs oval, small. Excretory vesicle Y-shaped, with ventroterminal or ventral opening; arms united anteriorly.

#### *Albulatrema* n. gen.

GENERIC DIAGNOSIS: Albulatrematinae, with characters of subfamily. Parasitic in swimbladder of marine or brackish water fishes.

TYPE SPECIES: *A. ovale* n. sp., in *Albula vulpes*; Hawaii.

#### 5. *Pseudobunocotyla awa* n. gen., n. sp.

Fig. 5

HABITAT: Stomach of *Chanos chanos* (local name "awa"); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 23.

DESCRIPTION (based on 10 whole mounts): Body cylindrical, without tail, 0.8–1.7 mm long, 0.14–0.35 mm wide at postacetabular ridge, which encircles the body. On each side this annular ridge, well provided with longitudinal subcuticular muscle bundles, may be a more or less prominent, blunt-pointed cone directed posterolaterad. Around the oral sucker is a collar-like ridge which, however, may be straightened out when the oral sucker is protruded, or shifted forward as a ring when the oral sucker is retracted. Oral sucker bowl-shaped, terminal,  $70-140 \times 70-120 \mu$ , directly followed by a small pharynx  $23-50 \times 35-60 \mu$ ; esophagus short, ceca widened anteriorly, terminating blindly near posterior extremity. Acetabulum large, prominent,  $0.19-0.37 \times 0.19-0.35$  mm, situated at junction of anterior with middle third of body.

Testes subglobular to oval,  $30-100 \times 32-110 \mu$ , postacetabular, slightly obliquely tandem in middle third of body, may or may not be separated by uterine coils. Vesicula seminalis tubular, sigmoid,  $25-70 \mu$  wide, overlapping anterodextral margin of acetabulum, with its tapering anterior end opening into pars prostatica. Pars prostatica rounded,  $40-70 \mu$  in diameter, lined with large vesicular epithelia and surrounded by large prostate cells which are delimited sharply from the surrounding parenchyma. At the distal end of the pars prostatica originates the wide eversible hermaphroditic duct which is lined with transversely wrinkled cuticle and enclosed in a muscular hermaphroditic pouch  $79 \mu$  in diameter in the type. Genital pore wide, median, opening immediately behind intestinal bifurcation.

Ovary subglobular to oval,  $42-70 \times 50-100 \mu$ , situated ventrally at anterior end of middle third of body. Receptaculum seminis large,  $60-120 \mu$  in greater transverse diameter, anterodorsal to ovary. Laurer's canal? Vitellaria



consisting of two compact oval masses measuring 37–60  $\mu$  by 46–100  $\mu$  and lying directly tandem immediately behind ovary; vitelline ducts united near their origin into a common duct which runs forward to the ootype situated dorsal to the ovary. Uterine coils descending to posterior extremity and then ascending, occupying all available space of hindbody; metraterm running forward ventral to pars prostatica and joining hermaphroditic duct at anterior end of pars prostatica. Eggs elliptical, 30–38  $\times$  13–20  $\mu$ . Excretory pore terminal; excretory vesicle tubular; excretory arms united anteriorly dorsal to pharynx or esophagus.

DISCUSSION: The present genus differs from *Bunocotyle* Odhner, 1928, in several important points, shown in Table 1.

*Genolinea ampladena* Manter and Pritchard, 1960, probably may be transferred to *Pseudobunocotyla*, although in this species the post-acetabular ridge represented by a mere transverse, ventral, cuticular line is stated by the authors to be present in three specimens and absent in three other specimens. It agrees completely with the present genus in general anatomy, especially in the terminal genitalia.

*Pseudobunocotyla* n. gen.

GENERIC DIAGNOSIS: Hemiuridae, Bunocotylinae.<sup>3</sup> Body cylindrical, without tail, with collar-like ridge around oral sucker and another immediately behind acetabulum. Oral sucker large, terminal; pharynx small, esophagus short,

ceca terminating separately near posterior extremity. Acetabulum very large, prominent, anterior. Testes tandem, postacetabular; seminal vesicle sigmoid, more or less overlapping acetabulum; pars prostatica large, surrounded by large prostate cells which are well delimited from the surrounding parenchyma. Hermaphroditic duct well differentiated, enclosed in muscular hermaphroditic pouch. Genital pore immediately postbifurcal. Ovary well separated from posterior testis by uterine coils; receptaculum seminis present. Vitellaria consisting of two compact masses situated directly tandem immediately behind ovary. Uterine coils reaching posterior extremity when fully developed. Eggs small, elliptical. Excretory vesicle tubular; arms united dorsal to pharynx or esophagus. Stomach parasites of marine or brackish water teleosts.

TYPE SPECIES: *P. awa* n. sp., in *Chanos chanos*; Hawaii.

6. *Quadrifoliovarium pritchardi* n. gen., n. sp.  
Fig. 2 A–B

HABITAT: Stomach and pyloric ceca of *Naso unicornis* (local name “kala”); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 24.

DESCRIPTION (based on 17 whole mounts): Body elongate, cylindrical, smooth, 3.0–9.0 mm long by 0.2–0.6 mm wide, tapered at each extreme end. Mouth opening ventrosubterminally. Oral sucker 0.11–0.28  $\times$  0.15–0.29 mm, surmounted by rounded conical preoral lobe 40–90  $\mu$  thick, directly followed by well-developed pharynx 0.06–0.15 mm long by 0.08–0.15 mm wide; esophagus 80–220  $\mu$  long, provided with well-developed longitudinal muscle fibers. Ceca

TABLE 1  
DIFFERENTIATING CHARACTERISTICS OF *Bunocotyle* AND *Pseudobunocotyla*

CHARACTER	<i>Bunocotyle</i>	<i>Pseudobunocotyla</i>
Ceca	united posteriorly	terminating separately
Prostatic complex	poorly developed or lacking	very strongly developed
Vitellaria	single	double, tandem
Receptaculum seminis	absent (?)	present

<sup>3</sup> Subfamily diagnosis given in *Systema Helminthum*, vol. 1 (p. 267–268) must be emended so as to include *Pseudobunocotyla*.



comparatively wide, terminating at different levels near posterior extremity. Acetabulum wider than long, 0.23–0.42 mm in transverse diameter, situated in posterior half of anterior third of body, with a pair of muscular, auricular, ventrolateral lobes immediately behind; each of these lobes is constricted near its anterior end, 0.27–0.73 mm long, widest at middle of elliptical posterior portion; each lobe consists almost exclusively of dorsoventral muscle fibers, but some fibers which are located close to the point where the lobe is attached to the body are continued into the body parenchyma, so that the postacetabular lateral area of the body shows a dense marginal layer of strong transverse muscles.

Testes rounded,  $0.1\text{--}0.26 \times 0.11\text{--}0.3$  mm, directly tandem in ventral part of midregion of body. Seminal vesicle saccular, up to 0.13 mm wide immediately in front of anterior testis, whence it tapers and passes into a much coiled tubular portion. Pars prostatica 0.12–0.35 mm long, surrounded by a dense coat of prostate cells which is well delimited from the surrounding parenchyma. Ejaculatory duct following pars prostatica long and narrow, uniting with uterus at base of hermaphroditic pouch. Hermaphroditic duct muscular, smooth, convoluted in hermaphroditic pouch, up to 0.4 mm long when fully everted; hermaphroditic pouch elliptical to pyriform,  $0.08\text{--}0.26 \times 0.06\text{--}0.2$  mm, with comparatively thin walls of mainly longitudinal muscle fibers, a little posterior to intestinal bifurcation; genital pore midventral, 0.44–0.83 mm from head end.

Ovary divided into four spherical to oval, subequal lobes, measuring 0.13–0.4 mm longitudinally as a whole, situated ventrally at posterior part of middle third of body. Seminal receptacle voluminous, inverted retort-shaped, 0.08–0.4 mm in transverse diameter, situated immediately anterodorsal to ovary with its distal end produced backward. Shell gland complex immediately posterodorsal to ovary. Vitellaria divided into two rosette-shaped groups which are united together by a longitudinal collecting duct passing between the two ventral ovarian lobes, each group consisting of six or seven digitiform lobes totaling 12 or 14; anterior group

overlapping ovary and seminal receptacle; posterior group ventral to shell gland, with forwardly directed lobes overlapping ovary. Uterus descending near ventral cuticle down to cecal ends where it turns dorsad and ascends dorsal to the descending portion, ovary, seminal receptacle and testes. Anterior to the testes it runs alongside the male duct and finally joins the latter at base of hermaphroditic pouch where it is provided with a small sphincter. Uterine eggs numerous, elliptical, operculate, embryonated,  $25\text{--}30 \times 12\text{--}16 \mu$  in life. Excretory vesicle cylindrical,  $80 \times 70 \mu$  in lateral view in the type, with terminal pore; divided anteriorly into two wide lateral arms running forward and reaching to oral sucker or pharynx where they unite dorsally. In the young specimen 3 mm long the two lateral excretory arms are in direct contact with each other in median line behind the acetabulum.

**DISCUSSION:** From the internal anatomy of the genitalia it seems certain that this genus is related to *Lecithasterinae* Odhner, 1905. On the other hand it bears a certain resemblance to *Accacoeliidae* Looss, 1912, in which, however, the excretory stems are located dorsally and ventrally in the hindbody but laterally in the forebody and not united anteriorly. The paired postacetabular flaps should be regarded as an accessory adhesive organ without great taxonomic importance. I prefer, therefore, to propose a new subfamily *Quadrifoliovariinae* and place it near *Lecithasterinae* Odhner, 1905 and *Trifoliovariinae* Yamaguti, 1958.

#### QUADRIFOLIOVARIINAE n. subf.

**SUBFAMILY DIAGNOSIS:** *Hemiuridae*. Body long, slender, smooth. Preoral lobe prominent. Oral sucker and pharynx well developed; ceca terminating near posterior extremity. Acetabulum anterior, with a pair of muscular accessory adhesive flaps immediately behind. Testes tandem, ventral, in midregion of body. Seminal vesicle winding, prostatic cells well developed, both between acetabulum and anterior testis. Ductus hermaphroditicus enclosed in hermaphroditic pouch. Genital pore postbifurcal. Ovary distinctly lobed, ventral, posttesticular; seminal receptacle present. Laurer's canal? Vitellaria

consisting of two groups of digitiform lobes. Uterus first descending ventrally to near posterior extremity, then ascending dorsally. Excretory vesicle terminal, bifurcating into wide lateral arms united anteriorly.

*Quadrifoliovarium* n. gen.

GENERIC DIAGNOSIS: Hemiuridae, Quadrifoliovariinae. Body slender, tapered at both extremities. Oral sucker subterminal, directly followed by muscular pharynx; esophagus short, muscular; ceca terminating blindly near posterior extremity. Acetabulum transversely elongate, in anterior third of body; postacetabular muscular flaps constricted near anterior end. Testes directly tandem, in equatorial zone. Vas deferens swollen proximally immediately in front of anterior testis, but tapered and convoluted as it proceeds anteriorly; pars prostatica surrounded by compact layer of prostate cells, immediately anterior to winding tubular seminal vesicle; ejaculatory duct narrow, straight, running alongside terminal portion of uterus. Ductus hermaphroditicus slender, unarmed, muscular, extremely long when fully everted; hermaphroditic pouch elliptical to oval, thin-walled. Genital pore midventral, shortly postbifurcal. Ovary four-lobed, in anterior part of posterior half of body. Receptaculum seminis voluminous, immediately anterodorsal to ovary. Vitellaria divided into two (an anterior and a posterior) groups of digitiform lobes, largely overlapping ovary. Uterus extending backward and then forward dorsal to ovary and testes; metraterm not differentiated; eggs elliptical, small, embryonated. Excretory vesicle divided near posterior extremity into two wide lateral arms running forward and uniting dorsal to oral sucker or pharynx. Gastro-intestinal parasites of marine teleosts.

TYPE SPECIES: *Q. pritchardi* n. sp., in *Naso unicornis*; Hawaii.

(A posteriorly mutilated specimen of this species, collected by Dr. H. L. Ching, stained with carmine and mounted in balsam was kindly submitted to me by Mrs. Mary Hanson Pritchard, together with her sketches and description; for these I am greatly indebted, because this slide showed the anterior union of

the excretory arms and the structure of the terminal genitalia more clearly than my own specimens stained with Heidenhain's hematoxylin. This is why I prefer to dedicate the species in question to our esteemed fellow taxonomist, Mrs. Pritchard.)

7. *Lobatovitelliovarium fusiforme*

n. gen., n. sp.

Fig. 6

HABITAT: Intestine of *Ablennes bians* (local name "aha'aha"); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 25.

DESCRIPTION (based on six whole mounts): Body fusiform, small, with posterior extremity projecting in form of a truncate cone, 0.72–1.13 mm long, 0.35–0.47 mm wide at level of acetabulum. Cuticle thick, smooth. No eye spots. Oral sucker subventral, 70–110  $\times$  80–140  $\mu$ , surmounted by inconspicuous preoral lobe, directly followed by muscular pharynx 23–80  $\mu$  long by 39–90  $\mu$  wide. Esophagus about 50  $\mu$  long, forming a barrel-shaped thickening of circular and longitudinal muscles posteriorly; ceca simple, passing dorsal to testes, opening into cloaca close to posterior extremity. Acetabulum large, largely postequatorial, 0.3–0.4 mm in diameter, with transversely elongated oblong aperture, the anterior and posterior margins of which are provided with semicircular lamellar muscle fibers.

Testes oval to elliptical, 0.1–0.21  $\times$  0.07–0.15 mm, situated symmetrically one on each side of acetabulum. Seminal vesicle ovoid, 0.14–0.2  $\times$  0.1–0.11 mm, medial to right cecum anterior to right testis and acetabulum, with its anterior end tapering anteriorly and passing into pars prostatica dorsally. Pars prostatica short, running dorsoventrally behind intestinal bifurcation and surrounded by prostate cells which form very thick compact layer, sharply delimited from the surrounding parenchyma. Neither ejaculatory duct nor cirrus differentiated. Genital atrium sucker-like, with midventral opening immediately behind intestinal bifurcation.

Ovary divided into four rounded to oval lobes, measuring 60–150  $\times$  130–190  $\mu$  as a whole, situated between two cecal ends, with



oval to transversely elongated seminal receptacle immediately behind. Vitellaria divided into six or seven compact lobes, measuring  $90\text{--}110 \times 130\text{--}170 \mu$  as a whole, situated immediately anteroventral to ovary, partly overlapping it and a little to left of median line. Laurer's canal? Uterus forming transverse loops between vitellaria and acetabulum as well as in front of acetabulum, finally opening into genital atrium from behind; eggs oval, small,  $16\text{--}19 \times 10\text{--}12 \mu$ . Excretory vesicle tubular, enlarged to form cloaca before opening terminally, divided dorsal to vitellaria into lateral collecting vessels, each of which runs forward along the lateral margin of the body.

**DISCUSSION:** As indicated by the name this new genus is characterized by the ovary and vitellaria being divided into compact lobes and lying in the caudal third of the body. From an anatomical point of view it bears a more marked resemblance to *Aerobiotrema* Yamaguti, 1958 than to any of the other known genera, although it is different ecologically. I would like to propose a new family Lobatovitelliovariidae with the genus as type, placing it near the Aerobiotrematidae.

#### LOBATOVITELLIOVARIIDAE n. fam.

**FAMILY DIAGNOSIS:** Digenea with large ventral acetabulum. Body small, tapering toward each extremity. Oral sucker and pharynx well developed; ceca opening into cloaca. Testes symmetrical, lateral, in acetabular zone. Vesicula seminalis and prostatic complex strongly developed. Genital pore midventral, postbifurcal. Ovary and vitellaria lobate, in caudal third of body. Uterus forming transversely elongated loops, metraterm not differentiated, eggs small, operculate. Excretory vesicle Y-shaped in general pattern, cloaca well developed. Intestinal parasites of marine fishes.

**TYPE GENUS:** *Lobatovitelliovarium* n. gen.

#### *Lobatovitelliovarium* n. gen.

**GENERIC DIAGNOSIS:** Lobatovitelliovariidae. Oral sucker subterminal, directly followed by pharynx; esophagus short, with bulbous swelling posteriorly; ceca running dorsal to testes, opening into cloaca at posterior extremity.

Acetabulum much larger than oral sucker, largely postequatorial. Testes one on each side of acetabulum. Seminal vesicle voluminous, pre-acetabular; pars prostatica surrounded by dense mass of prostate cells sharply delimited from surrounding parenchyma. No hermaphroditic duct. Genital atrium with sucker-like midventral opening behind intestinal bifurcation. Ovary divided into four lobes, close to posterior extremity. Seminal receptacle immediately post-ovarian. Vitellaria consisting of several compact lobes, immediately anteroventral to ovary. Uterus winding just anterior and posterior to acetabulum; eggs numerous, small, oval. Excretory vesicle tubular, narrow, enlarged to form wide cloaca at posterior extremity, bifurcating behind acetabulum; collecting vessels not uniting anteriorly. Parasitic in intestine of marine teleosts.

**TYPE SPECIES:** *L. fusiforme* n. sp., in *Ablennes bians*; Hawaii.

#### 8. *Lobatocystis yaito* n. gen., n. sp.

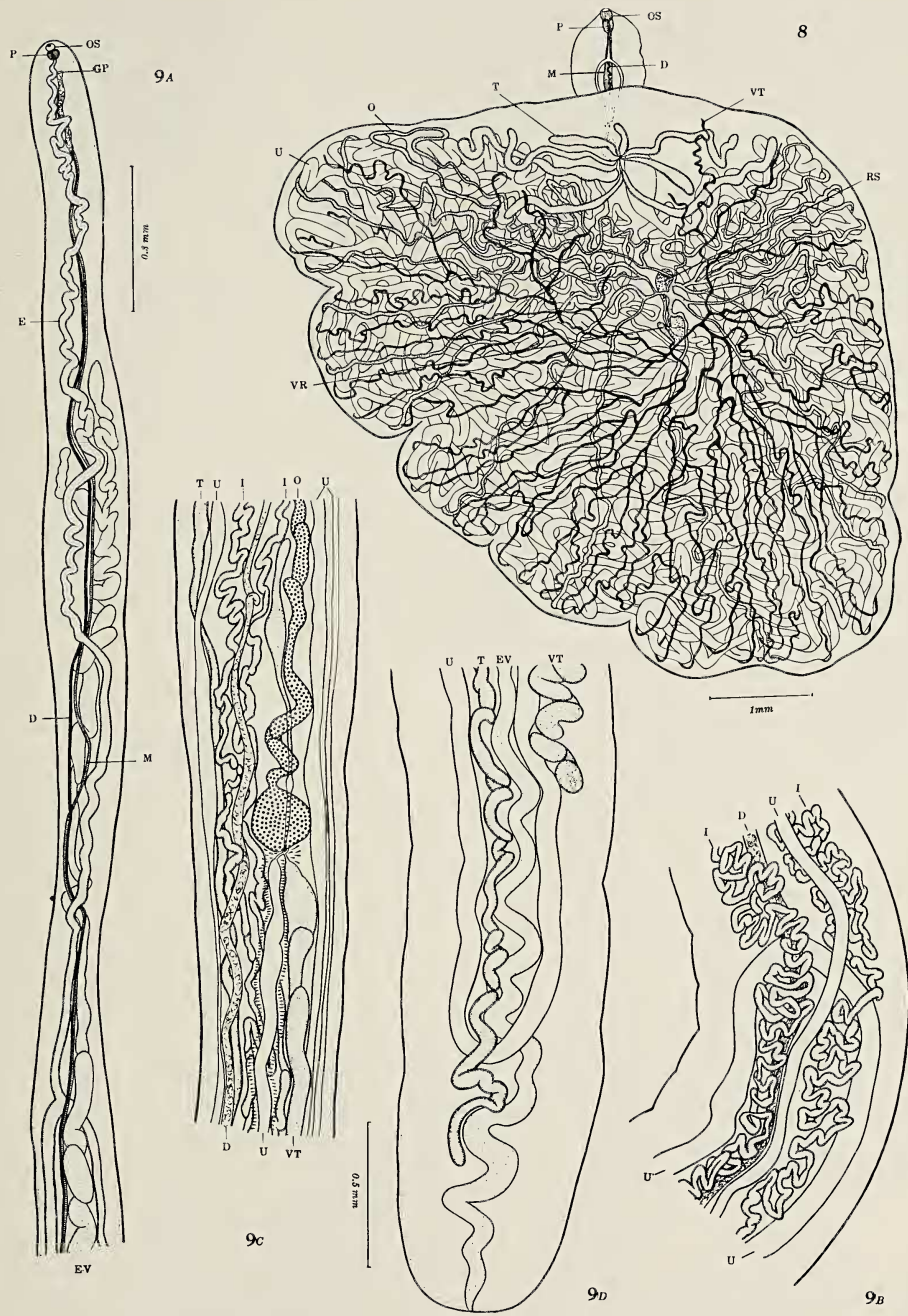
Fig. 8

**HABITAT:** Encysted in pairs in gill arch of *Euthynnus yaito* (local name "kawakawa"); Hawaii.

**HOLOTYPE:** U. S. Nat. Mus. Helm. Coll., S.Y. No. 26.

**DESCRIPTION** (based on five whole mounts): Body flat, approximately triangular, with its convex side usually divided into six hemispherical lobes, and its flat anterior edge in direct contact with the corresponding edge of its fellow-occupant of the cyst; the forebody arising from this side is pressed flat against the flat surface of the hindbody, another rather flat side of the hindbody being on the same plane as the corresponding side of the other partner, so that the two individuals are enclosed in an elongated, flattened hemispherical cyst. Forebody scoop-shaped, 1.5–2.6 mm in length, with maximum width of 0.74–1.05 mm at level of intestinal bifurcation. Oral sucker prominent,  $0.11\text{--}0.16 \times 0.12\text{--}0.18$  mm, directly contiguous to pharynx, latter  $0.14\text{--}0.2 \times 0.13\text{--}0.2$  mm; the two organs appear like a single organ. Esophagus slender, 0.2–0.5 mm long; ceca narrow in forebody, but inflated in hindbody and apparently terminating near posterior extremity.





FIGS. 8-9. 8, *Lobatocystis yaito* n. gen., n. sp.; holotype, dorsal view. 9, *Allometanematobothrioides lepidocybii* n. gen., n. sp. 9A, anterior part of paratype, dorsal view. 9B, region of anterior uterine loop of holotype, ventral view. 9C, region of genital junction of holotype, dorsal view. 9D, posterior extremity of holotype, dorsal view.

Testes divided into eight long, tubular, unbranched lobes which are arranged radially from posterior end of vas deferens at base of forebody, the length of the lobes varying from 0.5 to 1.3 mm, and the width from 0.09 to 0.15 mm in the type. Vas deferens winding forward along with metraterm and opening together with latter ventral to oral sucker.

Ovary tubular, slender, irregularly ramified in the central region, sending slender branches into each marginal lobe. It is not possible to make out how many branches there are, because of their being intertwined with uterine coils and vitelline tubules. In *Didymocystis* the ovarian tubules are confined to a particular portion of the hindbody, but in the present genus they extend throughout the hindbody without being confined to a particular region. Receptaculum seminis retort-shaped, 0.25 mm in diameter, situated near the point where the main ovarian tubes meet and join the vitellarian stem. Vitellaria divided into numerous branches, which finally reach the peripheral area of the hindbody, where they form loops ending blindly. Uterus strongly convoluted, looping back on itself many times close to surface of each marginal lobe as well as on other sides, but not forming a definite egg reservoir before leading into metraterm. Metraterm well provided with circular muscles, running straight forward in intercecal field of forebody. Eggs small, somewhat bean-shaped, thin-shelled,  $12.5-15 \times 7.5 \mu$ .

DISCUSSION: This new genus is characterized by the peculiar shape of the hindbody which is usually lobed on one side, the multiple testes being radially arranged in the anterior part of the hindbody, and the ovary, uterus, and vitellaria being intertwined throughout the hindbody. It is defined as follows.

*Lobatocystis* n. gen.

GENERIC DIAGNOSIS: Didymozoidae, Didymozoinae. Forebody scoop-shaped, hindbody flattened into triangular form, with one margin

usually lobed and the other two margins straight. Oral sucker contiguous with pharynx; esophagus slender, bifurcating at level of widest part of forebody. Ceca probably terminating near posterior end of hindbody. Testes divided into eight long, unbranched tubules radiating from junction of vasa efferentia in anterior part of hindbody. Vas deferens winding forward in forebody along with metraterm and opening together with latter ventral to oral sucker. Ovary divided into slender branches reaching to peripheral area of hindbody. Receptaculum seminis retort-shaped. Vitellaria tubular, very slender, branched, intertwined among ovary and uterus, though extending mostly in peripheral area. Uterus strongly convoluted, occupying all available space of hindbody, without forming egg reservoir before entering forebody; eggs very small, somewhat bean-shaped, thin-shelled. Encysted in pairs in gill arch of marine teleosts.

TYPE SPECIES: *L. yaito* n. sp., in *Euthynnus yaito*; Hawaii.

9. *Allonematobothrium epinepheli*

n. gen., n. sp.

Fig. 10 A-E

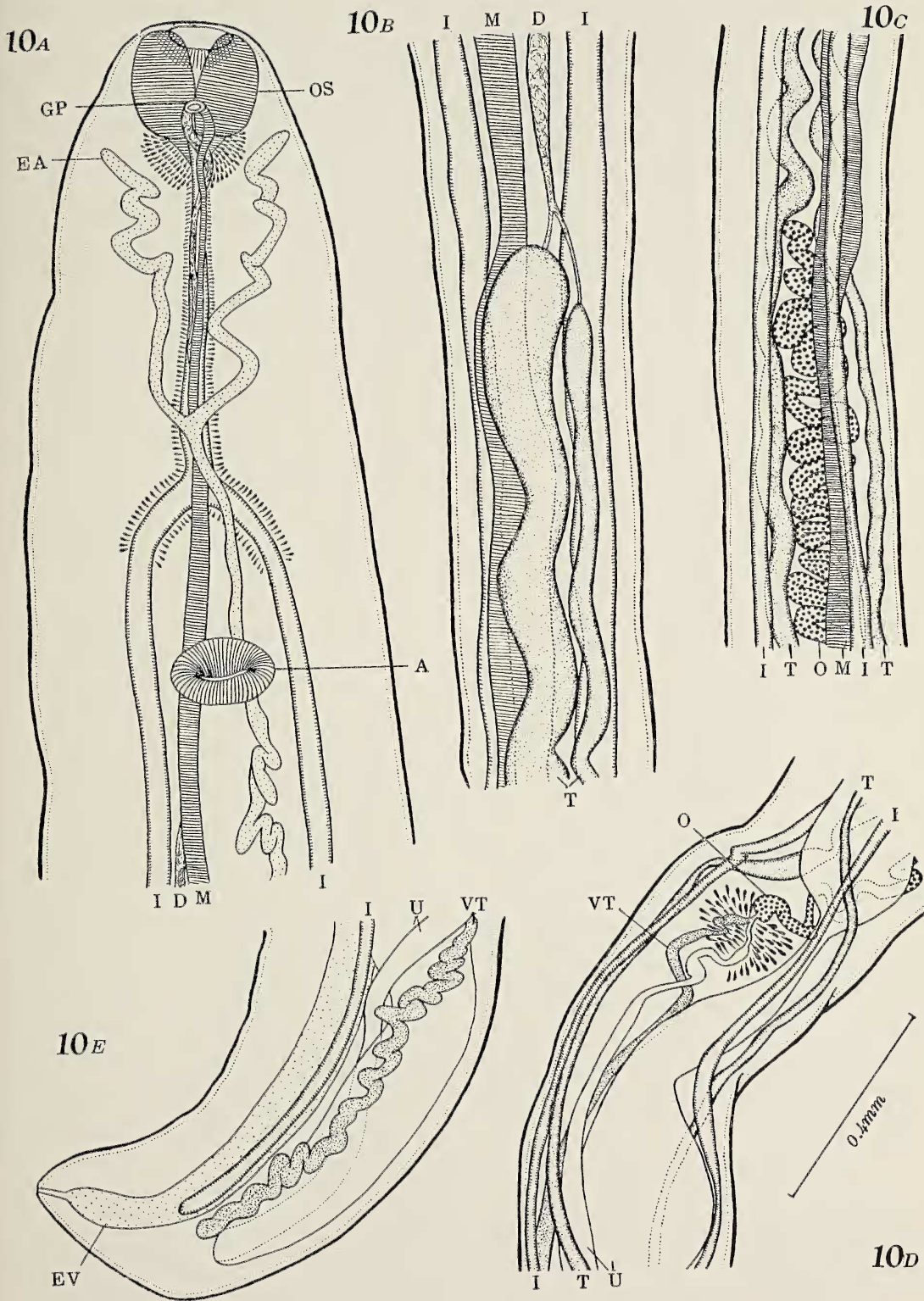
HABITAT: Encysted in pairs in fins and underside of operculum of *Epinephelus quernus* (local name "hapu'upuu"); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 27.

DESCRIPTION (based on seven whole mounts): Body slender, 70-365 mm long, up to 0.6-1.0 mm wide at irregular intervals where the ascending uterus is distended with eggs, somewhat swollen in acetabular region, blunt-pointed at posterior extremity. Oral sucker terminal, well developed,  $0.21-0.3 \times 0.24-0.3$  mm, directly followed by a funnel of transverse muscle fibers which in turn is surrounded by dense mass of glandular cells. Esophagus 0.5-1.0 mm long, provided with a layer of glandular cells appearing like accompanying cells, as is the very beginning of the intestinal limbs for a distance of about 0.2 mm in the type 183 mm

FIG. 10. *Allonematobothrium epinepheli* n. gen., n. sp. 10A, anterior extremity of holotype, ventral view. 10B, region of anterior part of testes of holotype, ventral view. 10C, region of anterior part of ovary of holotype, ventral view. 10D, region of genital junction of paratype. 10E, posterior extremity of holotype, lateral view.







long. Ceca simple, may reach posterior extremity, although more or less markedly atrophied posteriorly. Acetabulum prominent,  $0.11\text{--}0.18 \times 0.13\text{--}0.19$  mm, situated  $0.25\text{--}0.8$  mm behind intestinal bifurcation.

Testes two, juxtaposed, tubular, each commencing as a very narrow tubule  $6\text{--}30$  mm behind genital junction, more or less swollen at anterior end which lies at a distance of  $4\text{--}8$  mm from the head end, both usually terminating at slightly different levels. Vas deferens running alongside ascending distal portion of uterus. Genital pore median, ventral to oral sucker.

Ovary tubular, strongly winding in median field, unbranched, originating between two testes at a distance of  $4.5\text{--}20$  mm from head end,  $0.6\text{--}8.5$  mm behind anterior ends of testes. Germiduct short; no seminal receptacle. Genital junction  $14\text{--}60$  mm from head end,  $56\text{--}305$  mm from posterior extremity, dividing body in ratio of  $1:4\text{--}6$  ( $1:1.2$  in paratype 132 mm long). Uterine duct surrounded by shell gland cells, descending alongside vitelline gland, turning back on itself at posterior end of body or some distance (up to  $3.4$  mm) away from it, to be continued into final ascending uterus. The latter portion of uterus swollen at irregular intervals, differentiated into muscular metraterm some distance anterior to genital junction. Eggs bean-shaped,  $20\text{--}24 \times 8\text{--}10$   $\mu$  in life. Vitellarium tubular, winding irregularly, usually reaching to posterior extremity, originating  $3.0$  mm anterior to posterior extremity in one paratype in which the uterus also turns forward far away from the posterior extremity. In this specimen the posteriormost portion of the body looks like a slender tail. Excretory vesicle winding, bifurcating immediately in front of intestinal bifurcation; arms winding.

DISCUSSION: This genus is distinguished from the related genera according to the characters presented in Table 2.

### *Allonematobothrium* n. gen.

GENERIC DIAGNOSIS: Didymozoidae, Nematobothriinae. Body slender, very long, swollen at irregular intervals in gravid specimens. Oral sucker strongly muscular; pharynx practically

absent, though a funnel-shaped swelling is present at the anterior end of the esophagus. Esophagus and beginning of ceca surrounded by glandular cells. Ceca simple, may reach posterior extremity, more or less atrophied posteriorly. Acetabulum present. Testes paired, originating posterior to genital junction, terminating a short distance anterior to ovary. Ovary single, tubular, unbranched, intertesticular. No seminal receptacle. Uterus first descending, looping at posterior extremity alone. Vitellarium tubular, unbranched, extending between genital junction and posterior extremity. Excretory vesicle with terminal pore, bifurcating anteriorly into short arms. Encysted in pairs in fins or underside of operculum of marine teleosts.

TYPE SPECIES: *A. epinepheli* n. sp., in *Epinephelus quernus*; Hawaii.

### 10. *Allometanematobothrioides lepidocybii* n. gen., n. sp.

Fig. 9 A-D

HABITAT: Free in the periaortal connective tissue of *Lepidocybium flavobrunneum*; Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 28.

DESCRIPTION (based on two whole and one mutilated specimens): Body filiform, gradually tapered anteriorly to a blunt point,  $38$  mm in entire length, with maximum width of  $0.7$  mm in the somewhat flattened, intact, type specimen, one of the entire paratypes being  $30$  mm long. Oral sucker rounded, ventroterminal, rather cellular,  $23\text{--}25$   $\mu$  in diameter, followed directly by a muscular pharynx  $18\text{--}23$   $\mu$  long by  $23\text{--}30$   $\mu$  wide. Esophagus narrow, strongly winding,  $1.16$  mm long lineally in the type, but  $2.6$  mm long in the mutilated paratype. Ceca narrow, winding, rather convoluted and running in median field for greater posterior portion, but tending to atrophy posteriorly, terminating about  $12$  mm from posterior extremity in the type. No acetabulum.

Testes double, tubular, winding; in the type the anterior testis originates about  $5$  mm behind the genital junction and terminates  $6.3$  mm from the anterior extremity, whereas the posterior testis arises close to the posterior ex-

TABLE 2  
COMPARISON OF *Allonematobothrium* WITH RELATED GENERA

CHARACTER	<i>Nemato- bothrium</i>	<i>Allonemato- bothrium</i>	<i>Nemato- bothrioides</i>	<i>Metanemato- bothrium</i>	<i>Metanemato- bothrioides</i>	<i>Neonemato- bothrium</i>	<i>Allometanema- tobothrioides</i>
Body	encysted in pairs	encysted in pairs	free	free	free	free	free
Pharynx	present	absent	present	rudimentary	present	rudimentary	present
Esophagus	simple	simple	simple	simple	simple	unusually long, diverticulate, glandular	very long, winding, not diverticulate, not glandular
Ceca	simple	simple	simple	simple	simple	very narrow, convoluted	very narrow, convoluted
Acetabulum	present	present	absent	rudimentary	present	absent	absent
Testes	juxtaposed	juxtaposed	juxtaposed	juxtaposed	obliquely tandem	obliquely tandem	obliquely tandem
Ovary	undivided	undivided	undivided	divided	undivided	undivided	undivided
Uterus	first ascending, forming 2 loops	first descending, forming 1 loop	first descending, forming 1 loop	first descending, forming 3 loops	first descending, forming 1 loop	first descending, forming 3 loops	first descending, forming 3 loops

tremity (0.53 mm in the type, 0.16 mm in one entire paratype, from this extremity) and passes imperceptibly into the wide vas efferens which runs forward alongside the distal ascending uterus and unites with its fellow from the anterior testis a short distance anterior to the distal end of this testis; the vas deferens follows its median course all the way through alongside the distal uterus and finally opens midventrally together with the latter close to the anterior extremity a little behind the pharynx.

Ovary single, tubular, winding, unbranched, originating about 8 mm from the head end and terminating 2.2 mm from the same point in the type, where it is swollen into a pyriform mass 0.2 mm in diameter; the short germiduct arising from the posterior end of this ovarian mass soon joins the short ascending vitelline duct and leads into the uterine duct; the latter duct is at first rather straight but becomes twisted as it proceeds backward and is provided with a dense coat of shell gland throughout its descending course; after crossing the median ascending uterus, 3.2 mm behind the ovary in

the type, it leads into the straight narrow lateral ascending uterus. This ascending uterus turns backward across the ceca, distal ascending uterus, vas deferens, and excretory vesicle to take a descending course on the other side at a distance of 3 mm from the head end in the type. The descending uterus turns forward across the posterior testis and excretory vesicle 0.83 mm in the type and 0.24 mm in one entire paratype, from the posterior end to be continued as a final median ascending uterus, so that at a postovarian level there are seen four portions of the uterus, namely, descending uterine duct, proximal ascending, intermediate descending, and distal ascending uteri. Eggs bean-shaped,  $21-26 \times 12-16 \mu$ . Seminal receptacle very much elongated, extending forward from genital junction. Vitelline gland single, tubular, winding; originating near posterior extremity, 1.75 mm in the type and 0.6 mm in one entire paratype, from this end; it is straightened out distally to form an elongate vitelline reservoir about 0.1 mm wide in the type. Excretory vesicle tubular, winding, with almost terminal



pore, bifurcating into two unequal arms anteriorly at varying levels in esophageal region. Nerve commissure with a short anterior and a long posterior nerve trunk on each side, about 0.2 mm from head end in the type.

DISCUSSION: This genus is characterized by the following important features: (1) esophagus unusually long and winding; (2) ceca strongly convoluted for greater posterior part and running in median field rather than in lateral fields, atrophied posteriorly and not reaching posterior extremity; (3) testes tubular, double, obliquely tandem; extending greater part of body; (4) genital pore definitely postpharyngeal; (5) ovary single, tubular, unbranched, occupying greater middle portion of body; (6) uterus proper divided into three portions (proximal ascending, intermediate descending, and distal ascending); (7) no acetabulum. It bears a certain resemblance to *Metanematobothrioides*, but differs from it notably in all points except (5). It is defined as follows.

*Allometanematobothrioides* n. gen.

GENERIC DIAGNOSIS: Didymozoidae, Nematobothriinae. Body slender, very long, markedly tapered anteriorly. Oral sucker rudimentary, pharynx well developed. Esophagus long, narrow. Ceca strongly convoluted for their greater posterior part, tending to atrophy posteriorly, not reaching posterior extremity. Acetabulum absent. Testes double, tubular, winding, obliquely tandem, occupying greater posterior part of body. Genital pore ventromedian, definitely postpharyngeal. Ovary single, tubular, unbranched, occupying greater middle portion of body. Seminal receptacle present. Uterus first descending for a short distance, then ascending, turning backward in anterior part of body, finally turning forward at posterior extremity; eggs bean-shaped, small. Vitellarium tubular, extending from near posterior extremity to genital junction. Excretory vesicle with terminal pore, bifurcating anteriorly into two short arms.

Parasitic, free in tissues of marine teleosts.

TYPE SPECIES: *A. lepidocybii* n. sp., in *Lepidocybium flavobrunneum*; Hawaii.

11. *Metanematobothrioides opakapaka*

n. gen., n. sp.

Fig. 11 A-C

HABITAT: Submental connective tissue, inner surface and its opposite surface of operculum of *Pristipomoides microlepis* (local name "opakapaka"); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 29.

DESCRIPTION (based on six entire specimens and a number of fragments): Entire body length 32-44 mm in immature specimens, 247 mm in the longest mature specimen, not completely hermaphroditic in young individuals. Body slender, slightly flattened dorsoventrally; anterior extremity more or less acute. Oral sucker terminal, 62-103  $\times$  75-117  $\mu$ ; pharynx 28-38  $\times$  30-38  $\mu$ . Esophagus simple, 0.35-0.8 mm long, bifurcating about halfway between pharynx and acetabulum. Ceca surrounded by gland cells at beginning for a distance of 0.2-0.3 mm, terminating at posterior extremity. Acetabulum 60-100  $\mu$  long by 80-110  $\mu$  wide, 0.8-1.1 mm from head end.

Testes paired, tubular, originating at different levels, one at posterior extremity and the other far away (10-65 mm) from it, terminating at a distance of 2.0-4.2 mm from head end. Vas deferens running alongside uterus and joining metraterm at common opening ventral to oral sucker.

Ovary winding, tubular, 15-43 mm long lineally, originating 4.3-10.4 mm from head end; distal end of ovary swollen and containing numerous yolk cells in the type 127 mm long; germiduct may be inflated as it receives the duct from the vitelline reservoir and then leads into the uterine duct which is lined with a layer of epithelia and surrounded by shell gland cells. Genital junction very variable in position, dividing body in ratio of 1:1-6. No definite sem-

FIGS. 11-12. 11, *Metanematobothrioides opakapaka* n. gen., n. sp. 11A, anterior extremity of holotype, dorsal view. 11B, region of genital junction of holotype, ventral view. 11C, posterior extremity of paratype, lateral view. 12, *Nematobothrioides kalikali* n. gen., n. sp. 12A, anterior extremity of paratype, ventral view. 12B, region of genital junction of holotype, ventral view. 12C, posterior extremity of holotype, ventral view.

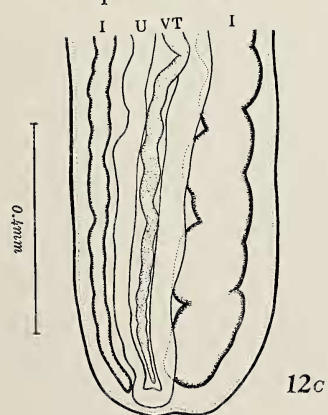
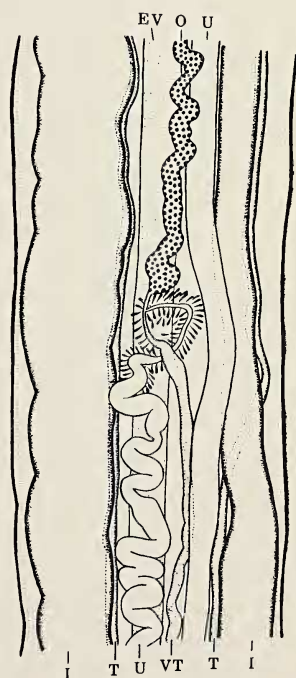
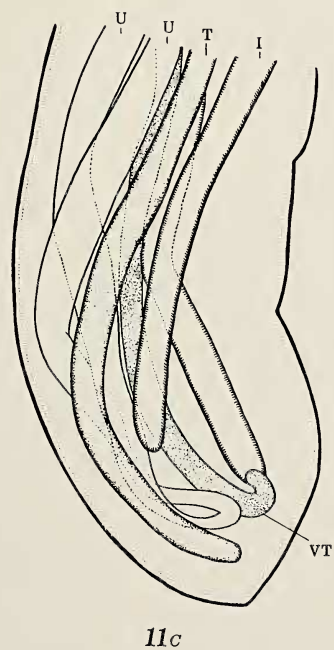
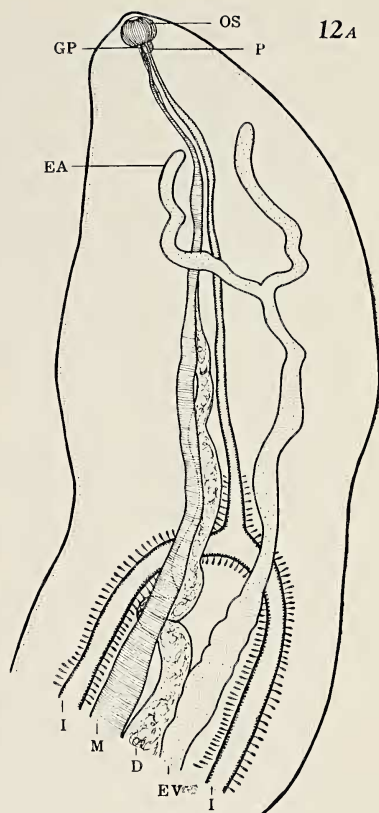
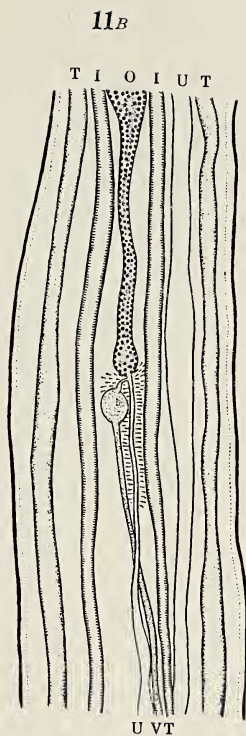
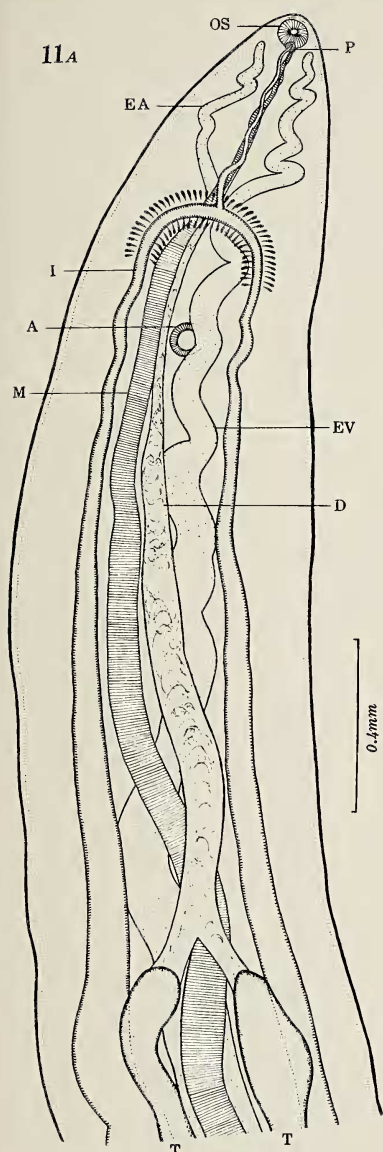




TABLE 3

DISTINGUISHING FEATURES OF *Metanematobothrium* AND *Metanematobothrioides*

CHARACTER	<i>Metanematobothrium</i>	<i>Metanematobothrioides</i>
Testes	turning back on themselves anteriorly	not turning back on themselves anteriorly
Ovary	divided	undivided
Receptaculum seminis	present	absent
Uterus	first descending, forming three loops	first descending, forming one loop

inal receptacle. Uterus proper first descending as far as posterior extremity, where it turns forward to be continued as ascending limb. Eggs bean-shaped,  $18-23 \times 11-14 \mu$ . Vitellarium a single, slender tube running straight backward from genital junction to posterior extremity along with uterus; just before joining the germiduct the vitellarium of the type is swollen into a bulbous reservoir  $50 \mu$  wide and distended with yolk cells. Excretory vesicle with terminal pore, bifurcating anteriorly into two short arms reaching to near nerve commissure.

DISCUSSION: This new genus presents several features by which it can be distinguished from the related genus *Metanematobothrium* (see Table 3).

*Metanematobothrioides* n. gen.

GENERIC DIAGNOSIS: Didymozoidae, Nematobothriinae. Body slender, very long. Oral sucker well developed, followed by small pharynx. Ceca surrounded by gland cells at beginning, terminating at posterior extremity. Acetabulum distinct, some distance behind intestinal bifurcation. Testes paired, tubular, sinuous, extending almost entire length of body in mature worms. Genital pore median, ventral to oral sucker. Ovary filiform, winding, unbranched, originating some distance behind distal ends of testes and descending to genital junction. No seminal receptacle. Uterus first descending, turning forward at posterior extremity; eggs elliptical, small. Vitellarium single, filiform, extending between ovary and posterior extremity. Excretory vesicle with terminal pore, bifurcat-

ing anteriorly into two short arms. Parasitic in marine teleosts.

TYPE SPECIES: *M. opakapaka* n. sp., in *Pristipomoides microlepis*; Hawaii.

12. *Nematobothrioides kalikali* n. gen., n. sp.  
Fig. 12 A-C

HABITAT: Free in subcutaneous connective tissue of opercular region of *Pristipomoides sieboldii* (local name "kalikali"); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 30.

DESCRIPTION (based on four flattened entire specimens and a fragmented specimen): Body filiform, slender, 35-70 mm long, 0.4-0.5 mm wide, more or less blunt anteriorly but rounded at posterior extremity. Oral sucker subterminal,  $23-70 \times 74-86 \mu$ , pharynx  $35-58 \times 46-56 \mu$ ; esophagus simple, straight or sigmoid posteriorly, 60-100  $\mu$  long, ceca surrounded by glandular cells to a considerable extent at the beginning like the posterior portion of esophagus, terminating blindly at extreme posterior end of body. Acetabulum absent.

Testes very narrow, tubular, juxtaposed, originating one on each side a little behind genital junction, winding forward, turning inwards across ceca at about level of anterior end of ovary to come to lie medial to ceca, where they run forward parallel to each other, finally meeting in median line at a distance of 3.4 mm from head end in the type. From the point of union the vas deferens runs forward along with the uterus and unites with it into a short common duct which opens ventrally immediately behind the oral sucker.

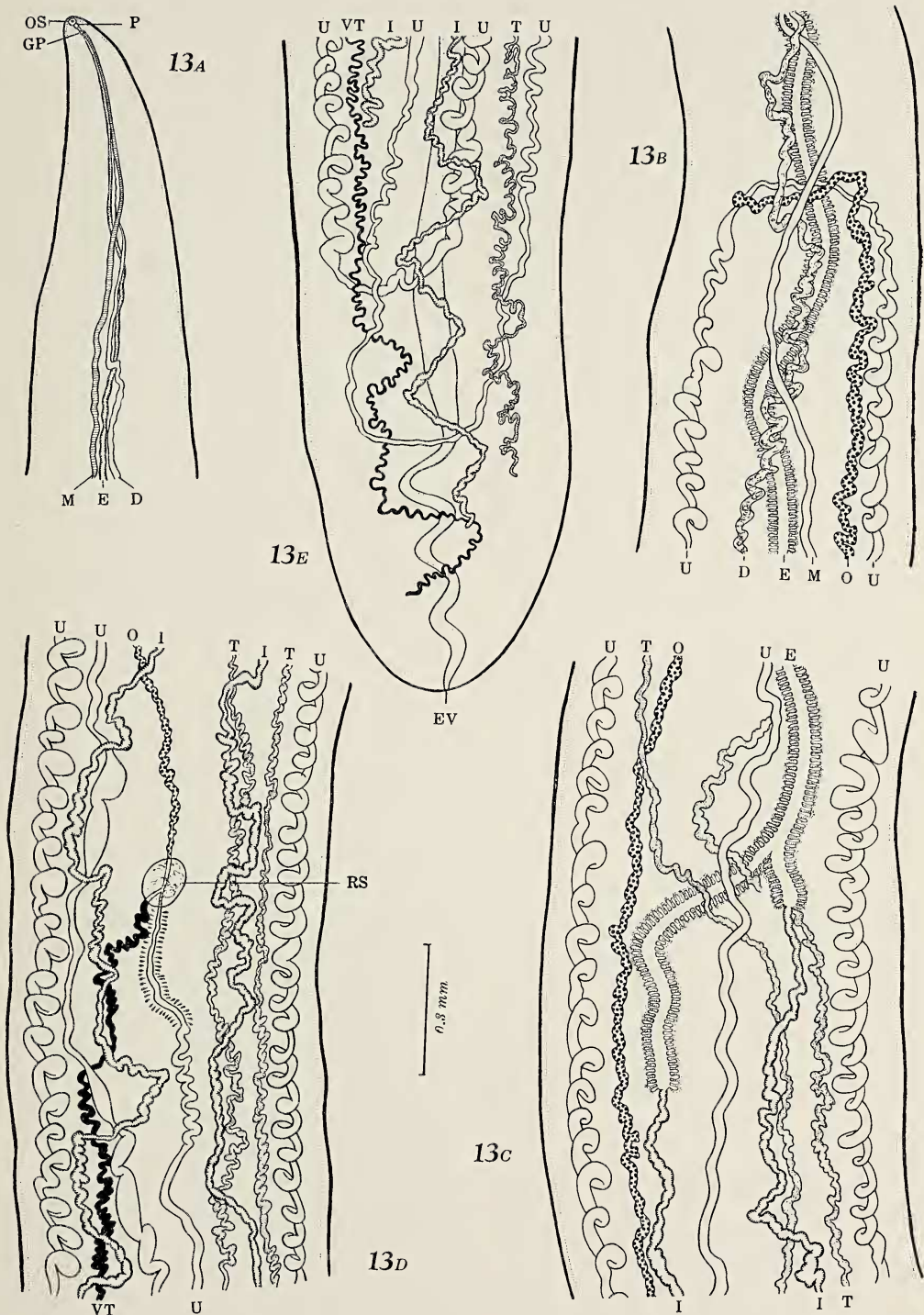


FIG. 13. *Neonematobothrium kawakawa* n. gen., n. sp. 13A, anterior extremity of holotype, ventral view. 13B, region of anterior part of ovary of holotype, ventral view. 13C, region of intestinal bifurcation of holotype, ventral view. 13D, region of genital junction of holotype, ventral view. 13E, posterior extremity of holotype, ventral view.



Ovary narrow, tubular, winding, arising at a distance of 4.2–10 mm from head end, but terminating at variable distances; in the type and one paratype the genital junction lies far anterior to the midbody, but far posterior to this point in the other two paratypes. Germiduct very short; seminal receptacle absent. Descending uterine duct strongly winding, surrounded by shell gland cells and studded with yolk cells for a distance of about 0.4 mm in the type, a short descending portion directly following it also strongly winding and distended with sperm. At the extreme posterior end of the body the descending uterus turns back on itself between the two cecal ends; the distal portion of the uterus runs straight forward along with the vas deferens; eggs oval,  $18\text{--}21 \times 11\text{--}14 \mu$ . Vitellarium narrow, tubular, extending from behind ovary to extreme posterior end of body.

DISCUSSION: This genus differs from *Nematobothrium* van Beneden in the following points: (1) free in host tissue; (2) ceca provided with well-developed gland cells at the beginning, terminating at posterior extremity; (3) testes paired, extending from behind genital junction to near anterior extremity; (4) ovary extending in testicular region; (5) uterus descending to posterior extremity where it takes its final ascending course.

#### *Nematobothrioides* n. gen.

GENERIC DIAGNOSIS: Didymozoidae, Nematobothriinae. Complete hermaphrodite free in host tissue. Body narrow, long, almost uniformly wide. Oral sucker larger than pharynx. Posterior end of esophagus and anteriormost portion of ceca surrounded by prominent glandular cells, ceca terminating at posterior end of body. Acetabulum absent. Testes juxtaposed. Genital pore ventral, close to pharynx. Ovary and vitellarium single, tubular, long, winding; former confined to testicular region, latter between ovary and posterior extremity. Uterus first descending to posterior extremity where it takes its final ascending course. Parasitic in subcutaneous connective tissue of marine teleosts.

TYPE SPECIES: *N. kalikali* n. sp., in subcutaneous connective tissue of opercular region of *Pristipomoides sieboldii*; Hawaii.

#### 13. *Neonematobothrium kawakawa*

n. gen., n. sp.

Fig. 13 A–E

HABITAT: Free in subcutaneous tissue of opercular region of *Euthynnus yaito* (local name "kawakawa"); Hawaii.

HOLOTYPE: U. S. Nat. Mus. Helm. Coll., S.Y. No. 31.

DESCRIPTION (based on three whole mounts): Body flattened, slender, 32–48 mm long by 0.07–0.65 mm wide (about 37 mm long by 70  $\mu$  wide in the type), tapered anteriorly to a sharp point, but rounded at posterior extremity. Cuticle smooth throughout. Oral sucker and pharynx rudimentary, 10–23  $\mu$  and 7–14  $\mu$  wide respectively. Esophagus simple and slender anteriorly, but profusely diverticulate on each side and surrounded by numerous small glandular cells for its greater posterior part, bifurcating in the type at a distance of 16.7 mm from head end into two limbs of similar structure and of unequal length; each limb is continued backward into a strongly twisted, narrow, tubular cecum, which terminates near the posterior extremity. No acetabulum.

Testes two, narrow, strongly twisted, parallel to each other for the most part, but originating at different levels; posterior testis originating 0.5 mm from tail end and anterior testis arising 12.5 mm further anteriorly in the type; each passing imperceptibly into vas efferens. In the type one vas efferens is swollen (50  $\mu$  across) before joining its fellow at a distance of 5.5 mm behind anterior end of ovary, 8.8 mm from head end. Vas deferens winding forward in median field close to final ascending limb of uterus. Common genital pore almost midventral, shortly behind pharynx.

Ovary narrow, twisted like testes, originating 2.0–3.7 mm posterior to head end just at the level where the proximal ascending uterus crosses the median line from the left to the right as in the type, or 1.1–2.4 mm further behind this level. It extends backward in the type for about 17 mm, turning from side to side several times, terminating at a distance of 20.5 mm from anterior extremity, where it joins the anterior end of the ascending vitellarium. This genital junction is, therefore, posterior to the midbody in the type as well as in one speci-

men 32 mm long, but in the longest specimens (48 mm) it lies anterior to the midbody dividing the body in ratio of 21:27. Seminal receptacle oval,  $100 \times 80 \mu$  in the type, situated dorsal to this point of genital junction. Descending uterine duct surrounded by shell gland for a length of about 0.4 mm in the type, turning forward in the type across median line from one side to the other at a distance of 0.9 mm from posterior extremity; this ascending uterine limb turns across the median line once more 3.3 mm posterior to the head end to take an exactly identical descending course on the opposite side and passes into the final ascending limb 0.55 mm from the posterior extremity; thus the entire uterus forms three loops, one at a short distance from the head end and two near the posterior extremity; distal portion of final ascending uterine limb differentiated into muscular metraterm which runs forward nearly in the median field along with the vas deferens; eggs bean-shaped,  $14\text{--}21 \times 7.5\text{--}12 \mu$ . Vitellarium narrow, tubular, strongly twisted throughout. In the type it originates 0.2 mm from posterior end of body and runs forward medial to proximal ascending uterine limb opposite testes. Excretory vesicle tubular, somewhat winding in median field, its anterior termination not made out; excretory pore terminal.

**DISCUSSION:** This genus bears a certain resemblance to *Allometanematobothrioides*, especially in that the uterus makes three U-turns (though turning first near the posterior extremity instead of posterior to the ovary), and in the intestinal limbs being very narrow and very strongly convoluted, and in the anterior extremity markedly tapering. But the two genera differ fundamentally in the structure of the esophagus.

*Neonematobothrium* n. gen.

**GENERIC DIAGNOSIS:** Didymozoidae, Nematobothriinae. Body long, slender, flattened, markedly tapered anteriorly. Oral sucker and pharynx rudimentary. Esophagus unusually long, with numerous diverticles surrounded by gland-

ular cells, bifurcating in midregion of body into unequal branches, each of which passes into a very narrow, convoluted cecum terminating near posterior extremity. Acetabulum absent. Testes narrow, twisted, parallel to each other for the most part, originating at different levels; posterior testis largely in greater posterior portion of body. Genital pore ventral, postpharyngeal. Ovary single, tubular unbranched, originating at level of anterior U-turn of uterus or further behind it. Seminal receptacle present. Uterus first descending to near posterior extremity, then ascending and turning backward a short distance back of anterior extremity, forming another U-turn near posterior extremity before taking its final ascending course; eggs bean-shaped, small. Vitellarium single, narrow, tubular, extending between ovary and posterior extremity. Excretory vesicle with terminal pore, probably bifurcating anteriorly. Parasitic, free in subcutaneous tissues of opercular region of marine teleosts.

**TYPE SPECIES:** *N. kawakawa* n. sp., in *Euthynnus yaito*; Hawaii.

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